In-vivo precision of the GE Lunar iDXA for the measurement of visceral adipose tissue in adults: the influence of body mass index

Running title: Precision of the iDXA for the measurement of visceral fat

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Abstract

CoreScan is a new software for the GE Lunar iDXA, which provides a quantification of visceral adipose tissue (VAT). The objective of this study was to determine the in-vivo precision of CoreScan for the measurement of VAT mass in a heterogeneous group of adults. 45 adults were recruited for this study (age 34.6 (8.6) years), ranging widely in body mass index (BMI 26.0 (5.2) $kg.m^{-2}$ (16.7 – 42.4 $kg.m^{-2}$). Each participant received two consecutive total body scans with re-positioning. The sample was divided into two sub-groups based on BMI, normal and overweight/obese, for precision analyses. Sub-group analyses revealed precision (RMS-SD:%CV) for VAT mass were 20.9g:17.0% in normal and 43.7g:5.4% in overweight/obese groups. Our findings indicate that the precision error for VAT mass increases with increasing BMI but caution should be used with %CV derived precision error in normal BMI subjects.

KEY WORDS: DXA; reproducibility; visceral fat; body composition

Introduction

Clinical investigations have demonstrated close relationships between regional fat mass and disease risk, mainly the association of trunk fat with the clustering of cardio-metabolic risk factors associated with metabolic syndrome (1). Abdominal obesity is also an independent predictor of all-cause mortality (2). Computed tomography (CT) is the gold standard assessment of visceral adipose tissue (VAT) but it is expensive and the high radiation exposure suggests the risks would outweigh the benefits if used as a screening tool. Dual-energy X-ray absorptiometry (DXA) provides a precise measurement of three compartment body composition (3). GE have recently introduced CoreScan; a new tool for the quantification of VAT, which has been validated with CT in healthy men and women (4). The advantages of using DXA over CT include the lower radiation exposure and greater time efficiency.

It is important to determine in-vivo precision of all DXA measurements for interpretation of results and patient monitoring. The purpose of this study was to ascertain the short term in-vivo precision of the GE Lunar iDXA CoreScan software for the measurement of VAT mass in normal, overweight and obese adults.

Materials/Subjects and Methods

Forty five men (n=10) and women (n=35) received two consecutive total body DXA scans with re-positioning, after providing signed informed consent to participate in the study approved by the Institution's Research Ethics Committee and in accordance with the Declaration of Helsinki.

Participants were measured wearing light weight clothing and all jewellery was removed. Height was determined with a stadiometer (SECA, Birmingham, UK) to the nearest 0.1cm, and body weight was recorded by calibrated electronic scales (SECA, Birmingham, UK) to the nearest 0.1kg. BMI was calculated as body mass in kilograms/ height in metres squared. Scans were conducted on a fan-beam GE Lunar iDXA using standard (153mm/sec) or thick (80mm/sec) mode depending on body stature. Participants were placed in the supine position on the scanning table with the body aligned with the central horizontal axis. Arms were positioned parallel to, but not touching the body. Forearms were pronated with hands flat on the bed. Legs were fully extended and feet were secured with a canvas and Velcro support to avoid foot movement during the scan acquisition. Each participant was re-positioned between scans, after dismounting the scanning table. One skilled technologist led and analysed all scans following the manufacturer's guidelines for patient positioning. Identical scanning parameters were used for each scan. The regions of interest for the total body cut-offs were manually adjusted according to the manufacturer's instructions. The ROI over the android region for the assessment of VAT was automated by the software. Scan analyses were performed using the Lunar Encore software (Version 15). The machine's calibration was checked and passed on a daily basis using the GE Lunar calibration hydroxyapatite and epoxy resin phantom. There was no significant drift in calibration for the study period.

Statistics

Data analysis was computed using Microsoft Excel 2010 and IBM SPSS Statistics software (Version 21). Participant descriptive data are reported as the mean and standard deviation (SD). The precision error is represented as the square root of the mean of the sum of the squares of differences between measurement 1 and measurement 2. The precision parameters, the root-mean-square standard deviation (RMS-SD), %CV (RMS-%CV), intra-class correlation coefficient (ICC) and the resulting least significant changes (LSC) were calculated manually. The %CV is derived from the equation:

$$\%CV = (SD/\text{mean value}) * 100.$$

Bland Altman analysis was used to compare the paired measurements (5).

Results and Discussion

According to the World Health Organisation BMI guidelines, 4% participants were underweight (n=2), 47% were classified as normal weight (n=21), 29% were overweight (n=13) and 20% obese (n=9). For analysis, the underweight and normal weight category were combined to form the 'normal weight group' (BMI = 22.1 (2.2) kg.m^{-2}; Age = 33.2 (8.6); n=20 female; n=3 male) with a range of

16.7-24.9 kg.m^{-2}; and the overweight and obese weight categories were combined to form a group (BMI = 30.0 (4.4) kg.m^{-2}; Age = 35.9 (9.0); n=15 female; n=7 male) with a rang of 25.5-42.4 kg.m^{-2}.

The overweight/obese group had greater VAT mass (mean of two measurements - normal : 123 (104)g; overweight/obese: 806.5 (564)g. Figure 1a and 1b illustrate Bland Altman VAT mass analysis for the two groups. For the normal BMI groups, mean of the differences = -2.3 ± 30.2 with limits of agreement -62.3g to 57.7g. For the overweight/obese group mean of the differences = 15.9 ± 61.1g with limits of agreement -106g to 138g was observed. Although the mean of the differences were small the range of inter-measurement differences increased with BMI. No magnitude effects were observed from Bland Altman analysis.

Table 1 shows the VAT mass precision and LSC at 95%CI for both groups and precision values determined from previous studies. For RMS-SD precision values, the normal BMI groups have a lower precision error: 20.9g but increased precision error with %CV: 17.0, compared to the overweight/obese group, 43.7g and 5.4% respectively. This is due to %CV being dependant on its inverse relationship with the mean value and in this study mean values of the two groups are different: 123g - 806g, resulting in the observed differences in %CV. Therefore the 95%CI derived from RMS-SD is the more reliable estimate. Our precision estimates for the overweight/obese group are in close agreement with the obese group precision values determined by Rothery et al (6). In the study of severely obese subjects by Carver et al (7) there is an marked increased in the RMS-SD precision error but only a small increase in the %CV precision error compared to the obese subjects due to the higher VAT mass mean value in the severely obese group.

We investigated precision error of the GE CoreScan VAT software in a heterogeneous sample of adults. This sample was representative of the usual research participants who attend our DXA centre. Using RMS-SD there was a small increase in the imprecision error with BMI in our study groups (20.9g compared to 43.7g). The RMS-SD and %CV precision values for the overweight/obese are similar to those reported by Rothney et al (6) due to the similar mean VAT masses. Our findings differ to those of Carver et al (7) who reported a RMS-SD precision for a severely obese group of 294g. A limitation of the study is that the effect of gender could not be investigated due to the low numbers of males. It should therefore provide a valuable avenue for future research.

We, and others, have previously reported excellent in vivo precision for iDXA measurements of total fat mass and total lean mass, regardless of BMI (3, 8). As suggested elsewhere, the visceral region is relatively small and the mathematical complexities to distinguish VAT from subcutaneous fat may lead to greater precision error (6). In conclusion, iDXA CoreScan provides good precision for VAT measurements for individuals with a BMI between 25.5 – 42.4 kg.m^{-2}, This study and comparisons with previous studies also highlights that the %CV value for precision should not be used when study population mean vales differ as observed in this study.

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Table Legends

Table 1: Precision comparison between two separate measurements of VAT mass.

Figure Legends

Figure 1: Bland-Altman plot between two measurements of VAT mass in the a) normal BMI group and b) the overweight and obese group

Table 1

BMI Classification	n	BMI (kg/m^2)	Vat Mass (g)	RMS-SD(g)		%CV	
					LSC(95%CI)		LSC(95%CI)
Normal*	23 (20f/3m)	22.1(2.2)	123	20.9	59.1	17.0	48.1
Overweight/Obese*	22 (15f /7m)	30.0(4.4)	806	43.7	123.6	5.4	15.3
Obese (6)	32f	35.1(3.1)	1110	56.8	160.7	5.1	14.4
Severely Obese (7)	55(36f/19m)	49.0(6.0)	3250	294.0	832.0	8.7	24.9

**Mellis et al (2014) - current study results*

KEY: RMS-SD - Root Mean Square of the Successive Differences; CV - Coefficient of Variation; LSC 95% CI - Least Significant Change at 95% Confidence Intervals

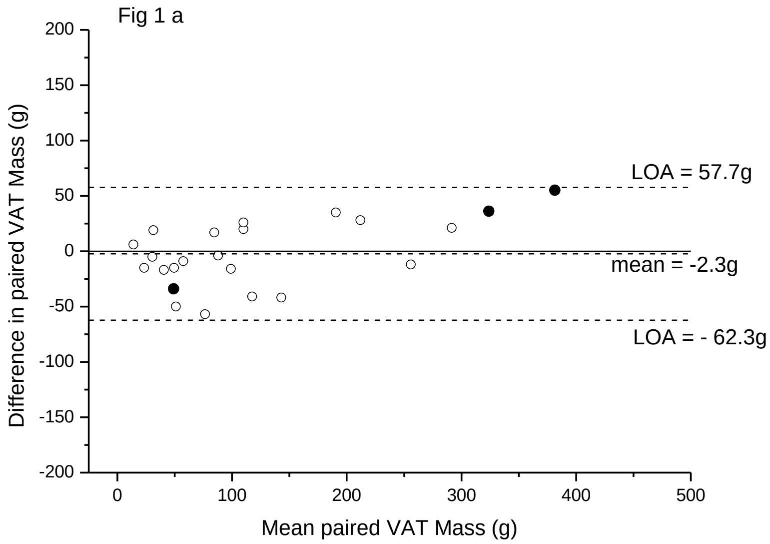
Fig 1 a
Difference in paired VAT Mass (g)
Mean paired VAT Mass (g)
LOA = 57.7g
mean = -2.3g
LOA = - 62.3g
200
150
100
50
0
-50
-100
-150
-200
0
100
200
300
400
500

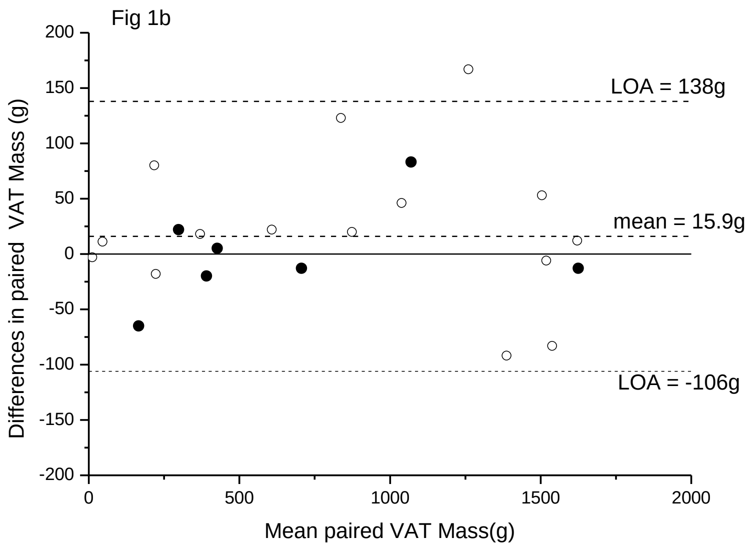
Fig 1b
Differences in paired VAT Mass (g)
Mean paired VAT Mass(g)
LOA = 138g
mean = 15.9g
LOA = -106g
200
150
100
50
0
-50
-100
-150
-200
0
500
1000
1500
2000